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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Shelaine Curd, Editors

Volume 137 BOREAS TE-5 Diurnal CO₂ Canopy Profile Data

J. Ehleriinger, J.R. Brooks, and L. Flanagan

National Aeronautics and Space Administration

Goddard Space Flight Center Greenbelt, Maryland 20771

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BOREAS TE-5 Diurnal CO₂ Canopy Profile Data

Jim Ehleringer, J.Renee Brooks, Larry Flanagan

Summary

The BOREAS TE-5 team collected several data sets to investigate the vegetation-atmosphere CO₂ and H₂O exchange processes. These data were collected to provide detailed information within the canopy during times when TE-05 sampled canopy CO₂ for carbon and oxygen isotope analysis. These measurements were made in both the NSA and SSA at the OJP, OBS, UBS, and OA sites from 25-May-1994 to 08-Sep-1994. CO₂ profile data were not collected at SSA-OA during the first IFC. The data are available in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-05 Diurnal CO₂ Canopy Profile Data

1.2 Data Set Introduction

The canopy CO₂ profile data were collected in both the Northern Study Area (NSA) and the Southern Study Area (SSA) during the 1994 Intensive Field Campaigns (IFCs).

1.3 Objective/Purpose

The data were collected to provide detailed information within the canopy during times when Terrestrial Ecology (TE)-05 sampled canopy CO₂ for carbon and oxygen isotope analysis.

1.4 Summary of Parameters

Time, CO₂ concentration at 9-m, 3-m, 1-m, 0.5-m, 0.25-m, and 0.05-m heights within the canopy at 10-min (NSA) or 30-min (SSA) intervals.

1.5 Discussion

These measurements were made at both the NSA and the SSA during each IFC at Old Jack Pine (OJP), Old Black Spruce (OBS), Upland Black Spruce (UBS), and Old Aspen (OA) sites. CO₂ profile data were not collected at SSA-OA during the first IFC.

1.6 Related Data Sets

BOREAS TE-05 Surface Meterological and Radiation Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

J.R. Ehleringer University of Utah Department of Biology

L. Flanagan Carleton University Department of Biological Sciences University of Lethbridge

2.2 Title of Investigation

Vegetation-Atmosphere CO₂ and H₂O Exchange Processes: Stable Isotope Analyses

2.3 Contact Information

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Dr. Larry Flanagan
Department of Biological Sciences
University of Lethbridge
4401 University Drive
Lethbridge, Alberta
T1K 3M4, CANADA
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(403) 329-2082 (fax)
larry.flanagan@uleth.ca

Contact 3:

Shelaine Curd Raytheon ITSS Code 923 NASA GSFC Greenbelt, MD 20771 (301) 286-2447 (301) 286-0239 (fax) shelaine.curd@gsfc.nasa.gov

3. Theory of Measurements

CO₂ was measured with the LI-COR LI-6262 infrared gas analyzer (IRGA). For theoretical information on the LI-6262, please refer to LI-6262 CO₂/H₂O Analyzer Operating and Service Manual, Publication # 9003-59, LI-COR, Inc., P.O. Box 4425, 4421 Superior Street, Lincoln, NE 68504, USA, toll-free telephone 1 (800) 447-3576 (USA and Canada), telephone (402) 467-2819.

The CO_2 profiles are a series of CO_2 concentrations measured on a vertical profile of air within the canopy. Tubing at various heights within the canopy was attached to a solenoid switching board (to switch height being monitored), through a pump, and into the IRGA (LI-6262). The IRGA was attached to a Campbell data logger so that CO_2 concentrations were recorded through time. The monitoring system ran continuously over a period of several days. More specific details are given below.

4. Equipment

4.1 Sensor/Instrument Description

CO₂ concentration was measured with the LI-COR LI-6262 IRGA. A Campbell CR-21x data logger was used to record the CO₂ data.

4.1.1 Collection Environment

The equipment operated under ambient environmental conditions during the measurement periods. Please see TE-05 Surface Meteorological and Radiation Data for specifics.

4.1.2 Source/Platform

CO₂ concentration was collected from a telescoping Rohn mast extending 9 m up into the canopy. Dekoron tubing was attached to the mast at six canopy heights.

4.1.3 Source/Platform Mission Objectives

This mission objective was to monitor diurnal changes in CO_2 concentration at six heights within the forest canopy.

4.1.4 Key Variables

Time, CO₂ concentration at 9 m, 3 m, 1 m, 0.5 m, 0.25 m, and 0.05 m.

4.1.5 Principles of Operation

An automated sampling system was set up at the site to monitor CO₂ when TE-05 was sampling canopy air for isotope analysis. Prior to setup in the field, the IRGA was calibrated in the lab, using the BOREAS standards. Every 10 min (NSA) or 30 min (SSA), CO₂ at each canopy height was monitored by the IRGA for 1.5 min before a 15-sec average reading was stored in the data logger. Air was pumped through 1/4-in. Dekoron tubing into the LI-6262 IRGA at the rate of 15 ml/sec. Every 3 hours, standard gases (0 ppm and 352 ppm) were measured to check IRGA calibration. The IRGA

temperature was also recorded so that temperature corrections for the zero could be made. All data were temperature corrected.

4.1.6 Sensor/Instrument Measurement Geometry

CO₂ data were collected from a Rohn mast extending 9 m up into the canopy. Dekoron tubing was attached to the mast at six canopy heights of 0.05, 0.25, 0.5, 1.0, 3.0, and 9.0 meters above the ground.

4.1.7 Manufacturer of Sensor/Instrument

LI-6262 IRGA: LI-COR, Inc. P.O. Box 4425 4421 Superior St. Lincoln, NE 68504 1 (800) 447-3576 (USA and Canada) (402) 467-2819

CR-21x Data logger: Campbell Scientific, Inc. P.O. Box 551 Logan, UT 84321 (801) 753-23425

4.2 Calibration

The LI-6262 IRGA was calibrated in the lab, using the BOREAS standards prior to setup at each field site, for each IFC. Once in the field, standard gases (0 ppm and 352 ppm) were measured to check IRGA calibration every 3 hours. IRGA temperature was also recorded so that temperature corrections for the zero could be made.

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

Prior to setup in the field, the IRGA was calibrated in the lab, using the BOREAS standards. Every 10 min (NSA) or 30 min (SSA), CO₂ at each canopy height was monitored by the IRGA for 1.5 min before a 15-sec average reading was stored in the data logger. Air was pumped through 1/4-in. Dekoron tubing into the LI-6262 IRGA at the rate of 15 ml/sec. Every 3 hours, standard gases (0 ppm and 352 ppm) were measured to check IRGA calibration. IRGA temperature was also recorded so that temperature corrections for the zero could be made. All data were temperature corrected.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

An automated sampling system was set up at the site to monitor CO₂ when TE-05 was sampling canopy air for isotope analysis. Prior to setup in the field, the IRGA was calibrated in the lab, using the BOREAS standards. Every 10 min (NSA) or 30 min (SSA), CO₂ at each canopy height was monitored by the IRGA for 1.5 min before a 15-sec average reading was stored in the data logger. Air was pumped through 1/4-in. Dekoron tubing into the LI-6262 IRGA at the rate of 15 ml/sec.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

Samples were collected at NSA OJP, SSA OJP, SSA OBS, and NSA UBS in 1993 and all the sites listed below in 1994. The North American Datum of 1983 (NAD83) coordinates of the sites are:

- NSA-OJP flux tower site, Lat/Long: 55.927°N, 98.62°W, Universal Transverse Mercator (UTM) Zone 14, N:6, 197,997 E:523,501.
- NSA-OA canopy access tower site (auxiliary site number T2Q6A, BOREAS Experiment Plan, Version 3), Lat/Long = 55.88°N, 98.67°W.
- NSA-UBS canopy access tower site (auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3), Lat/Long = 55.70°N, 98.51°W.
- SSA-OJP = Lat/Long: 53.91°N, 104.69°W.
- SSA-OBS = Lat/Long: 53.98°N, 105.12°W.
- SSA-OA = Lat/Long: 53.62°N, 106.19°W.

7.1.1 Spatial Coverage

- NSA-OJP flux tower site, Lat/Long: 55.927°N, 98.62°W, UTM Zone 14, N:6, 197,997 E:523,501.
- NSA-OA canopy access tower site (auxiliary site number T2Q6A, BOREAS Experiment Plan, Version 3), Lat/Long = 55.88°N, 98.67°W.
- NSA-UBS canopy access tower site (auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3), Lat/Long = 55.70°N, 98.51°W.
- SSA-OJP = Lat/Long: 53.91°N, 104.69°W.
- SSA-OBS = Lat/Long: 53.98°N, 105.12°W.
- SSA-OA = Lat/Long: 53.62°N, 106.19°W.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

These data are point source measurements.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

CO₂ profile data were measured at the sites from 02-Jun-1994 to 05-Sep-1994.

7.2.2 Temporal Coverage Map

CO₂ profile data were measured at the following sites during the following time periods.

IFC-1

NSA-OJP: 02-Jun-94, 7.32 Greenwich Mean Time (GMT) through 03-Jun-94, 16.32 (GMT)

NSA-OA: 10-Jun-94,16.15 (GMT) through 11-Jun-94, 19.98 (GMT)

NSA-UBS: 03-Jun-94, 2.15 (GMT) through 04-Jun-94, 2.15 (GMT)

SSA-OA: 29-May-94,1900 (GMT) through 30-May-94, 2150 (GMT)

SSA-OBS: 25-May-94, 1.50 (GMT) through 27-May-94, 20.00 (GMT)

SSA-OJP: 25-May-94, 2050 (GMT) through 27-May-94, 2.00 (GMT)

IFC-2:

NSA-OJP: 20-Jul-94, 21.48 (GMT) through 24-Jul-94, 22.32 (GMT)

NSA-OA: 31-Jul-94, 17.82 (GMT) through 05-Aug-94, 20.98 (GMT)

NSA-UBS: 25-Jul-94, 20.15 (GMT) through 29-Jul-94, 22.48 (GMT)

SSA-OA: 25-Jul-94, 1900 (GMT) through 27-JUL-94, 17.50 (GMT)

SSA-OBS: 20-Jul-94 20.50 (GMT) through 22-Jul-94, 15.50 (GMT)

SSA-OJP: 22-Jul-94, 2.50 (GMT) through 24-Jul-94, 18.00 (GMT)

IFC-3:

NSA-OJP: 30-Aug-94, 18.65 (GMT) through 01-Sep-94, 21.15 (GMT)

NSA-OA: 05-Sep-94, 19.32 (GMT) through 07-Sep-94, 18.65 (GMT)

NSA-UBS: 02-Sep-94, 18.48 (GMT) through 04-Sep-94, 16.15 (GMT)

SSA-OA: 03-Aug-94, 17.50 (GMT) through 05-Aug-94, 18.00 (GMT)

SSA-OBS: 31-Aug-94, 18.50 (GMT) through 02-Aug-94, 17.50 (GMT)

SSA-OJP: 06-Aug-94, 18.00 (GMT) through 08-Aug-94, 18.50 (GMT)

7.2.3 Temporal Resolution

A scan of each height was made every 10 minutes in the NSA and every 30 minutes in the SSA.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name

SITE_NAME

SUB_SITE

DATE_OBS

TIME_OBS

CO2_CONC

HT_AGL

CRTFCN_CODE

REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

| Column Name | Description |
|---------------|---|
| SITE_NAME | The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type. |
| SUB_SITE | The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument. |
| DATE_OBS | The date on which the data were collected. |
| TIME_OBS | The Greenwich Mean Time (GMT) when the data were collected. |
| CO2_CONC | CO2 concentration. |
| HT_AGL | The height above ground at which the measurements were taken. |
| CRTFCN_CODE | The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable). |
| REVISION_DATE | The most recent date when the information in the referenced data base table record was revised. |

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

| Column Name | Units | | |
|---------------|---------------------|--|--|
| SITE_NAME | [none] | | |
| SUB_SITE | [none] | | |
| DATE_OBS | [DD-MON-YY] | | |
| TIME_OBS | [HHMM GMT] | | |
| CO2_CONC | [parts per million] | | |
| HT_AGL | [meters] | | |
| CRTFCN_CODE | [none] | | |
| REVISION_DATE | [DD-MON-YY] | | |

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

| Column Name | Data Source |
|-------------|---------------------|
| SITE_NAME | [BORIS Designation] |
| SUB_SITE | [BORIS Designation] |
| DATE_OBS | [Human Observer] |
| TIME_OBS | [Human Observer] |

CO2_CONC [Laboratory Equipment]
HT_AGL [Laboratory Equipment]
CRTFCN_CODE [BORIS Designation]
REVISION_DATE [BORIS Designation]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

| | Minimum | Maximum | Missng | Unrel | Below | Data |
|--|--|---|------------------------------------|-----------------------------|-------------|--------|
| | Data | Data | Data | Data | Detect | Not |
| Column Name | Value | Value | | Value | Limit | Cllctd |
| SITE_NAME | NSA-9BS-9TE | TR SSA-OJP-FLXTR | | None | | None |
| SUB_SITE | 9TE05-C02P1 | 9TE05-C02P1 | None | None | None | None |
| DATE_OBS | 25-MAY-94 | 08-SEP-94 | None | None | None | None |
| TIME_OBS | 4 | 2358 | None | None | None | None |
| CO2_CONC | 3.5 | 958 | None | None | None | Blank |
| HT_AGL | .05 | 9 | None | None | None | None |
| CRTFCN_CODE | CPI | CPI | None | None | None | None |
| REVISION_DATE | | 12-AUG-97 | None | | | |
| Minimum Data Value The minimum value found in the column. Maximum Data Value The maximum value found in the column. Missng Data Value The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful. Unrel Data Value The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel. | | | | | | |
| | The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation. | | | | | |
| Data Not Cllctd | determine indicates not identi but this p | indicates that no the parameter valu that BORIS combine cal data sets into articular science at parameter. | ue. This ed severa o the sam | usuall l simil e data | Y ar but | le |

Blank -- Indicates that blank spaces are used to denote that type of value. N/A -- Indicates that the value is not applicable to the respective column. None -- Indicates that no values of that sort were found in the column.

7.4 Sample Data Record

The following is a sample of the first few records from the data table on the CD-ROM:

SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, CO2_CONC, HT_AGL, CRTFCN_CODE, REVISION_DATE
'NSA-9BS-9TETR','9TE05-CO2P1',03-JUN-94,209,363.0,9.0,'CPI',12-AUG-97
'NSA-9BS-9TETR','9TE05-CO2P1',03-JUN-94,209,362.2,3.0,'CPI',12-AUG-97

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by BORIS was the data collected at a given site on a given date.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

Not applicable.

9.1.1 Derivation Techniques and Algorithms

IRGA zero value changes as a function of temperature. To correct the data for this drift, standard gases (0 ppm and 350 ppm) and IRGA temperature were measured every 3 hours. A linear relationship was derived between temperature and the zero value. Using IRGA temperature, all data were corrected based on the linear relationship. The number was added to the observed data, and the correction was usually quite small, under 5 ppm.

9.2 Data Processing Sequence

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

IRGA zero value changes as a function of temperature. To correct the data for this drift, standard gases (0 ppm and 350 ppm) and IRGA temperature were measured every 3 hours. A linear relationship was derived between temperature and the zero value. Using IRGA temperature, all data were corrected based on the linear relationship.

9.3.2 Calculated Variables

Not applicable.

9.4 Graphs and Plots

Not applicable.

10. Errors

10.1 Sources of Error

None given.

10.2 Quality Assessment

10.2.1 Data Validation by Source

CO₂ was independently measured at 9 m and 0.5 m when TE-05 sampled CO₂ for isotope analysis. The concentration values from the isotope measurements were compared with these automated data sets. In all cases, the values are comparable.

10.2.2 Confidence Level/Accuracy Judgment

All known errors have been removed from the data.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

All known problems have been removed.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

These data can be used for profile isotope analysis.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The diurnal CO₂ canopy profile data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services Oak Ridge National Laboratory P.O. Box 2008 MS-6407 Oak Ridge, TN 37831-6407

Phone: (423) 241-3952 Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation None given.

17.2 Journal Articles and Study Reports

Brooks, J.R., L.B. Flanagan, G.T. Varney, and J.R. Ehleringer. 1995. Photosynthesis Profiles in Boreal Forest Canopies: Recycling of Soil-Respired CO₂. Ecological Society of America Annual Meetings, Snowbird, UT, 1995.

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Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

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Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

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17.3 Archive/DBMS Usage Documentation None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII - American Standard Code for Information Interchange

BOREAS - BOReal Ecosystem-Atmosphere Study

BORIS - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
DAAC - Distributed Active Archive Center

EOS - Earth Observing System

EOSDIS - EOS Data and Information System
GIS - Geographic Information System

GMT - Greenwich Mean Time

GSFC - Goddard Space Flight Center HTML - HyperText Markup Language IFC - Intensive Field Campaign IRGA - Infrared Gas Analyzer

NASA - National Aeronautics and Space Administration

NSA - Northern Study Area

OA - Old Aspen

OBS - Old Black Spruce OJP - Old Jack Pine

ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park

SSA - Southern Study Area

TE - Terrestrial Ecology

UBS - Upland Black Spruce

URL - Uniform Resource Locator

UTM - Universal Transporte More

UTM - Universal Transverse Mercator

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13. ABSTRACT (Maximum 200 words)

The BOREAS TE-5 team collected several data sets to investigate the vegetation-atmosphere CO_2 and H_2O exchange processes. These data were collected to provide detailed information within the canopy during times when TE-05 sampled canopy CO_2 for carbon and oxygen isotope analysis. These measurements were made in both the NSA and SSA at the OJP, OBS, UBS, and OA sites from 25-May-1994 to 08-Sep-1994. CO_2 profile data were not collected at SSA-OA during the first IFC. The data are available in tabular ASCII files.

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